Appendix K
Reliability, Availability, and Maintainability Issues: System Evaluation Considerations

K–1. Overview of reliability, availability, and maintainability

Reliability, availability, and maintainability (RAM) are important considerations in the acquisition of all systems. The degree of RAM evaluation required can vary widely from one system to another, depending on such factors as system complexity and technological maturity. This appendix defines the RAM related activities of T&E throughout the life cycle of a system. This guidance should be tailored for each program based on the level of complexity of the system, the acquisition phase, acquisition strategy, and the impact of RAM on the performance and suitability of the system. As presented, it illustrates comprehensive application to the most complex systems but is intended for selective application as appropriate.

a. Within the area of suitability, RAM is an important consideration in the acquisition of virtually all systems. RAM has a direct bearing on mission success, as well as on logistical considerations such as maintenance workload, sparing, level of repair decisions, training, and other operating and support cost factors.

b. The system evaluator, in coordination with other members of the T&E WIPT, is responsible for determining the extent and nature of RAM data required for the RAM portion of the system evaluation.

K–2. RAM definitions

a. Reliability is the duration or probability that a system can perform a specified mission for a specified time in a specified environment. Mission reliability is the reliability associated with completion of a specific mission profile. It addresses essential function failures that cause either loss of a mission essential function or degradation in performance below ORD requirement levels. It is noted that failures to meet performance requirements can also be caused by other factors, such as design shortcomings, and failure to achieve a performance requirement is not treated as a reliability problem unless it is the result of a reliability incident.

b. Maintainability is a measure of the ability of an item to be retained in, or restored to, a specified condition when maintenance is performed by personnel having specified skill levels and using prescribed procedures and resources, at each prescribed level of maintenance and repair. It reflects the ease and efficiency of performing both corrective and scheduled maintenance on a system.

c. Availability is the probability that a piece of equipment is in an operable and committable state at a given (random) point in time. Repair, maintenance, and administrative and logistics downtime are the most common causes of equipment non-availability for use. A system's availability is a function of its reliability and maintainability.

K–3. RAM requirements

The CBTDEV or Training Developer (TNGDEV) develops the ORD RAM requirements. The ORD RAM requirements provide the CBTDEV's best estimate of what is required to meet the users' effectiveness, suitability, and survivability needs but should also reflect what the MATDEV deems affordable and technically achievable within program funding, risk, and time constraints. The requirements are developed in coordination with the system evaluator through the ICT process. Three elements are required to define RAM requirements:

a. The parameters and their numerical values. The development of a reliability parameter usually assumes that the failure rate of the mature system will be constant over a long period. This assumption allows the requirement to be expressed, not as a probability, but as an easily measurable parameter directly related to reliability. In test and evaluation the mission reliability parameter is normally one of the following:

— Mean Time Between Essential Function Failures (MTBEFF).
— Mean Time Between Mission Aborts (MTBMA).

If the system has another measure of usage other than time, the parameter is expressed with those units, such as miles, rounds, or events between failures. For single shot devices, such as a missile system, reliability is expressed as a ratio of number of successes to number of total attempts.

b. The Operational Mode Summary/Mission Profiles (OMS/MP) describes the individual missions that the system is required to perform and the conditions (climate, terrain, and battlefield environment.) under which the missions are to be performed.

(1) The OMS is a description of the anticipated mix of ways the system will be used in performing its operational role. It includes the expected percentage of use in each role and the percentage of time it will be exposed to each type of environmental condition.

(2) The MP is a time-phased description of the operational events and environments an item will experience from beginning to end of a specified mission (including the criteria for mission success or critical failures). The MP is used as the basis for the mission reliability requirement. The MP can be multifunctional (for example, a tank shooting, moving, and communicating), single-function continuous (that is, continuously performing one task), single-function cycle (that is, repeatedly performing the same task), or single-function one-time.

c. The Failure Definition and Scoring Criteria (FD/SC) are a set of rules designed to provide consistency in the

interpretation (such as, scoring) of reliability test incidents. The FD/SC define the required functionality and allowable levels of degradation (what constitutes a failure) and establishes a framework for classifying and charging test incidents. The FD/SC is a living document that may evolve as the program progresses and the system configuration and operation evolve.

K–4. Developmental and operational RAM

Both the developmental and operational aspects of RAM are important considerations throughout system development and fielding. A system that meets hardware/software developmental test requirements when tested individually in a controlled environment may not meet mission requirements in an operational environment where it must interact with soldiers and other systems.

a. Data from developmental testing are required to ensure RAM maturity of the hardware/software prior to entering an operational test. Developmental RAM examines the RAM characteristics based only on the hardware and embedded software of the system. It focuses on the extent to which the system meets technical RAM specifications and reflects those failures for which the system contractor is accountable.

b. Operational RAM considerations for a system relate to its hardware, embedded software, typical operators and maintainers, manuals, tools, Test, Measurement, and Diagnostic Equipment (TMDE), support equipment, and the operational, organizational, and logistical support concepts. Operational RAM quantifies the degree to which the user can rely on required system functions and the burden associated with keeping those functions at his or her disposal. The operational RAM assessment cannot be disassociated from the operational scenarios in which the system must function or from the support environment on which the system must rely.

K–5. RAM management

The management of a RAM program is primarily the responsibility of the MATDEV, who is responsible for establishing and overseeing contracts that result in reliable and maintainable systems. The MATDEV should assess the potential impact of RAM on O&S cost and the comparative risk associated with the various alternative concepts to achieve RAM requirements. Reliability Centered Maintenance (RCM) techniques are recommended to coordinate maintainability design efforts with maintenance planning. Acquisition and program planning should include early investment in RAM engineering tasks to avoid later cost and/or schedule delays.

a. RAM planning should encompass RAM program requirements, program tasks, reliability growth expectations, contract provisions, test plans, and resources necessary to support these plans. The MATDEV should keep the status of RAM development visible throughout the program and should plan for contractor reviews; data collection; failure reporting, analysis, and corrective actions; failure review boards; and testing and feedback mechanisms, as necessary, to provide insight into design, development and supportability progress, surveillance, and control.

b. Technical reliability thresholds and objectives derived from the operational requirements normally reflect only the hardware and software associated with the CFE and GFE. The threshold can be used as the minimum acceptable reliability value in the contract. Before contracts are finalized, the MATDEV should coordinate contract RAM requirements with the CBTDEV, matrix support elements, and system evaluators. Both technical and operational RAM requirements are to be demonstrated with high statistical confidence. High confidence is usually considered to be the 80 percent level; however, tailoring based on test cost or mission criticality is encouraged and the chosen confidence/risk value should be reflected in the TEMP.

c. Solicitations and contracts should provide adequate visibility into system development to assure that systems are designed to meet RAM requirements, that RAM performance can be effectively tested, and that compliance with requirements can be evaluated.

d. The MATDEV ensures appropriate consideration is given to the following factors in program planning:

— Failure modes, effects, and criticality analysis (FMECA).
— A Test, Analyze and Fix (TAAF) process.
— Use of RAM conferences to independently assess and monitor the growth process.
— System level testing to confirm achievement of interim and final RAM requirements.
— A closed loop, Failure Reporting/Analysis and Corrective Action System (FRACAS).
— Accelerated growth testing—testing at stress conditions higher than normal to precipitate failures at a faster rate.
— Engineering failure mechanism analyses (such as, Physics-of-Failure Analyses)

e. Reliability growth methodology, MIL–HDBK–189, provides an effective tool for planning and evaluating system reliability and an effective baseline against which actual growth can be managed. The MATDEV should apply reliability growth management methodology on all programs at the system level and, whenever practical, at the subsystem and major component level.

f. The MATDEV continuously assesses the performance of developed and fielded systems to identify opportunities for system RAM improvements, either through capability enhancement or through support burden and O&S cost reduction.

g. Throughout the materiel life cycle, the MATDEV maintains a historical audit trail of RAM development that includes but is not limited to—

— RAM requirements, to include the FDSC and OMS/MP.
— RAM planning documentation, current and historical growth curves, and contractual RAM provisions.
— Test data (to include type of test, system configuration, test conditions, test length, failures, data analysis, problems, root-cause failure analysis, and corrective actions).
— RAM status at key points in development, production and field operation.
— RAM improvements.

K–6. Evaluation planning

Evaluation planning is oriented toward providing data with which to estimate the technical and operational RAM values expressed in the requirements document. Tests are designed to ensure that statistically adequate estimates of RAM values are provided. The system evaluator is responsible for analyzing system RAM characteristics and evaluating RAM characteristics and performance. This requires selective participation in acquisition events, input to select planning documents, and development of a plan to quantify system RAM characteristics in terms of mission objectives. This plan requires the system evaluator's understanding of and input to the definitions of the operating and support environments, the operational tasks required of the system, acceptable levels of task performance, and the relationship of tasks to mission objectives.

a. The SEP reflects the system evaluators and testers' plan for the T&E of system RAM and its relation to the technical requirements and the operational effectiveness and suitability of the system. The RAM technical characteristics and the RAM critical and additional operational issue(s) provide the vehicle for translating the RAM related requirements into criteria, measures of performance, and data requirements in planning.

b. Coordination within the T&E WIPT must occur early in the planning process to ensure that RAM requirements and RAM data collection systems are adequately defined and to allow adequate time to set up RAM software programs, develop data collection plans, and conduct training prior to the pilot test.

K–7. RAM Subgroup of the T&E WIPT

The RAM Subgroup of the T&E WIPT reviews, classifies (that is, the RAM Scoring Conference scoring of test incidents), and charges (that is, assignment of causality) RAM data from system level tests. All data from system level RAM testing that record degradation from anticipated system performance should be scored in accordance with FD/SC. See DA Pam 70–3 for detailed guidance.

a. The RAM WIPT is made up of representatives from the MATDEV, CBTDEV, TNGDEV, and the independent system evaluator and may be augmented by others as appropriate. The testers should attend in an advisory capacity. Official scoring (that is, classification and chargeability) is the responsibility of the MATDEV, CBTDEV (or TNGDEV), and the system evaluator.

b. The TEMP is annotated to reflect those tests for which the system evaluator will serve as chair for RAM Scoring Conferences. The MATDEV chairs all other RAM groups. Prior to the first meeting, the chair coordinates with the participating organizations to establish membership, establish a common understanding of the system requirements, and identify a single voting member from each organization.

c. RAM WIPTs should meet periodically during system level testing, and a final meeting should be held at the conclusion of each test.

K–8. RAM Assessment Conference

The purpose of the RAM Assessment Conference is to establish a final RAM database from which assessment of operational and technical RAM requirements and specifications will be made. The Assessment Conference determines the viability of aggregating individual test databases and determines the impact of validating corrective action on that data. See DA Pam 70–3 for detailed guidance.

a. The system evaluator is responsible for chairing the RAM Assessment Conference. Membership is the same as the RAM Scoring Conference.

b. A RAM Assessment is usually held at the completion of an acquisition phase or before a program decision.

K–9. Contractor participation in RAM Scoring and Assessment Conferences

By law, system contractor personnel will not attend or be directly involved as members or observers in RAM Scoring or Assessment Conferences that address data intended to support evaluation of the system's operational RAM parameters.

a. Discussions with system contractor personnel are held separately from scoring and assessment activities. If the MATDEV needs access to contractor expertise during the conference, the chair may, at his or her discretion, recess the meeting to permit consultation with the contractor. The chair may, subject to the dissent of any spokesperson, allow the MATDEV to provide a contractor technical presentation on a pertinent aspect of the system to the members during the recess. Conference members may question the contractor representatives regarding the incident but may not discuss any

proposed scoring with the contractor present. The Scoring or Assessment Conference chair maintains a written record of the nature of the contractor/Government discussions.

b. This restriction applies to the scoring of DT data if the results may be used to support the evaluation of the system's operational RAM parameters.

K–10. Corrective action process

This process begins at the RAM Scoring Conference or in cases of critical incidents at the time of the incident.

a. As part of the evaluation of test events, the RAM Scoring Conference designates responsibility for investigating the incident, initiating corrective action, and reporting the results. Activities responsible for corrective action include the MATDEV for hardware, software, TMDE, manuals, and support equipment; the tester for failures caused by improper test conditions; and the CBTDEV for failures related to training and operational concepts. Each activity initiates appropriate corrective actions and provides a detailed analysis of these incidents to the members of the RAM Assessment Conference. The MATDEV takes the lead in the analysis of failure incidents, and sponsors corrective action reviews as appropriate. The status of corrective actions will be provided to the RAM Assessment Conference members.

b. After the test, the MATDEV may call a Corrective Action Review Team (CART) meeting. The CART process is a tool that supports the MATDEV's required corrective action review process. Its purpose is to determine adequacy and effectiveness of planned and implemented corrective actions. The CART is usually composed of the same members as the RAM Assessment Conference. In developing estimates of projected system RAM characteristics, results of the CART are considered. These estimates or projections may be included in the system evaluation and compared to the system's RAM requirements.

K–11. Use of reliability growth/projection methodologies in the T&E process

Reliability growth methodologies will be used, where appropriate, to assess program progress toward meeting developmental and operational reliability requirement parameters and thresholds. Growth methodology application may be useful in the event that OT reliability results are not demonstrated with confidence due to test duration limitations. Given compatibility with respect to test environments (and model fit), the growth tracking curve may be extended to include the OT data point (estimate) resulting in a new estimate based on augmented data. Projection methodologies can be used as risk mitigation tools in ascertaining readiness to enter the next test phase based on the previous completed test phase and identified delayed fixes. Projections are never to be utilized as a means to "demonstrate" reliability requirements. In addition, projection methodologies may be used in RAM Assessment Conferences for determining a projected reliability (based on a fix effectiveness assessment) when the reliability estimate (based on test results) falls below the requirement/threshold at a milestone decision point). This can provide useful information regarding risk relative to reliability achievement and whether to enter the next acquisition phase. Unique application of growth or projection methodologies may require support from AMSAA.